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Midsagittal Jaw Motion and Multi-Channel Analysis for Sleep-Disordered Breathing Screening

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Abstract

Sleep represents a third of our life, from birth to death. Sleep allows our body and mind to rest, and breaking its structure may lead to severe physical and nervous damage. Breathing disorders, like apneas, hypopneas or respiratory effort related arousal (RERA) events, alter the recovering feature of sleep by fragmenting its structure. They usually lead to daytime sleepiness, depression, hypertension, cardiovascular disease, . . . In order to give the most suitable treatment to a patient, the gold standard polysomnography (PSG) is recorded in a hospital setting and the huge amount of data is visually analyzed the day after. The PSG is expensive, time-consuming for the clinicians and unpleasant for the patients. Thus, portable monitoring devices and automatic analysis methods are welcome.

Four physiological parameters are required to score the three breathing disorders mentioned above: nasal airflow, oximetry, an arousal marker and a respiratory effort marker. While arousals are defined by frequency changes in the electroencephalogram traces, the esophageal pressure is the gold standard but invasive measure of effort. Surrogates (signals) exist for both arousal marker, like peripheral arterial tonometry, pulse transit time or electrocardiogram, and effort marker, like thoracic-abdominal movements, pulse transit time or forced oscillation technique. This thesis was dedicated to a novel one, the maxillo-mandibular movements (jaw movement in the midsagittal plane). This signal is not only able to point arousals and effort, but it has also the capability to distinguish sleep from wake as a mandibular actimeter, like the wrist actigraphy. These three features make it worth of interest.

At first, the jaw movement signal essence was extracted, automatic methods 1) to point arousals, 2) to indicate periodic patterns like respiratory effort or salvo of sleep events, 3) to detect and classify apnea, hypopnea and RERA events and 4) to separate sleep from wake were developed and evaluated. Then, the sleep apnea/hypopnea and the sleep/wake detectors were then improved by adding the oximetry. Finally, the nasal airflow brought its potential in both detection and classification of breathing disorders, es-

pecially to overcome the inherent classification problem between apneas and hypopneas since the jaw movements sensor is an effort sensor.

All the sleep apnea and hypopnea detection methods developed in this thesis were applied to a huge database of 150 consecutive recordings at the Sleep Laboratory of the University of Liège for sleep apnea and hypopnea detection assessment. Moreover, an automated positive air pressure (APAP) device, that applies a regulated pressure throughout a nasal mask to prevent from upper airway collapsing, was designed using only features computed in real-time from jaw movements and showed similar results to the widely tested *iS20i* from BREAS.

In conclusion, the maxillo-mandibular movement signal does bring useful information about respiratory effort and arousals. Coupled with the nasal flow and oximetry signal, the signal processing of these three physiological parameters provides an accurate detection and classification of sleep apneas, hypopneas and RERA. Besides, this jaw actimeter and its *ad-hoc* algorithm allows to distinguish sleep from wake. All in all, the jaw movement signal is a very valuable and a unique physiological signal for home sleep studies.

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